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Romania's accession to the Eurozone – a simulation using a simple DSGE model

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Abstract. *In this paper we present a simulation where Romania is a member of the Economic and Monetary Union (EMU); for this purpose we make use of a simple two-country Dynamic Stochastic General Equilibrium (DSGE) model linking Romania to the Eurozone. This research is motivated by the perspective of Romania entering in the EMU and by the poor research about the structural differences between these two economies and, also, about the macroeconomic effects of Euro area accession. In the first part we present the difference between the parameters describing the agent's decision-making in Romania and Euro area. The estimation showed that there is a degree of heterogeneity between the structural parameters describing the agents' behaviour, but a larger degree of heterogeneity can be observed at the volatility and at the synchronization of the structural shocks; the shocks that are hitting the Romanian economy are more volatile than those that affect the Eurozone. Because we have a micro-founded analysis of both economies, we can easily analyse the impact of losing monetary policy autonomy. In the absence of autonomous monetary policy, the most important stabilizer for a newly entered economy in the EMU is the competitiveness channel. To assess the importance of the competitiveness channel, the impulse response functions before and after Romania entry in the EMU are plotted. The simulation showed that the autonomous monetary policy plays an important role in stabilizing the Romanian economy after an internal originated shock and, thus, the competitiveness channel isn't able to stabilize the economy in a reasonable period; the inflation and the output are in general more volatile in the case where Romania is a member of the EMU.*

Keywords: two-countries; DSGE model; Bayesian estimation; Eurozone; heterogeneity.

JEL Classification: F36.
REL Classification: 20H.

1. Introduction

It is largely accepted in the literature that joining a common currency union comes with costs and benefits; the benefits of a monetary union can be summarized in the following advantages: lower transaction costs, lower interest rates and trade creation. Now, regarding the costs, Mundell (1961) clearly states that asymmetric shocks can negatively affect a member of a monetary union because joining a currency area reduces the policy tools available for mitigating these shocks. Also, there are cost arising from micro and macroeconomic differences; in order for a currency area to be optimal, the value of the parameters describing agents behaviour should be the same. We propose using a small two-country DSGE model for testing the above mentioned hypothesis for the Romanian economy. From our point of view, DSGE models are suitable for this kind of analysis because they are based on microeconomic foundations with rational agents and optimizing behaviour. Also, from our knowledge this kind of simulation has never been done for the Romanian economy.

The model that we have chosen was developed by Kolasa (2009) to assess the heterogeneity between Poland and Eurozone. We take the analysis even further, after estimating the model, when the values of the structural parameters are available we use them in a simulation where Romania is a member of the Euro area. The main idea is that after accession the competitiveness channel is substituting the monetary policy, via the exchange rate, for the role of stabilizing the economy. In order to carry out this simulation we have dropped the exchange rate equation and the monetary policy rule for the Romanian economy; after these modifications in the model there is only the interest rate set by the European Central Bank.

Now, turning to some key findings, it seems that there is some degree of heterogeneity between Romania and the Eurozone, namely, the habit in consumption is much lower than Euro area counterpart, the capital adjustment cost are almost 50% larger in Romania, the prices are adjusting more rapidly in Romania, the indexation of prices with past inflation is also higher than in Euro area and the shocks that are hitting the Romanian economy are three times more volatile; the simulation exercise is based on the analysis of macroeconomic adjustments after an internal structural shock. After this exercise we cannot conclude that the costs are larger than the benefits or vice versa of Romania accession to the Euro area. After some structural shocks the economy is adjusting more quickly under EMU and the opposite is true, but joining a common currency area creates a larger volatility in output and inflation after an internal generated structural shock.

The remaining of the paper is organized as follows: in section 2 is presented a brief literature review, followed, in section 3, by the presentation of some key equations; in section 4 is presented the estimation methodology and the results, in section 5 is presented a more in-depth analysis of the implications of Euro area accession for the Romanian economy and in section 6 are presented the conclusions and the directions for further work.

2. Brief literature review

Dynamic stochastic general equilibrium (DSGE) models have become a very powerful tool for describing economies, mainly due to the rigorous treatment of the microeconomic foundations describing the behaviour of the agents. The presence of microeconomic foundations allows for a more detailed and structured analysis of the origins of the business cycle fluctuations than can be provided by a-theoretical econometric models (e.g. VAR models).

The literature regarding costs and benefits attributed to the Euro era accession is rather limited; the main source is the National Bank of Poland where there are research papers dealing with this fact(1). Kolasa (2009) makes a pre-EMU analysis and is testing for sources of heterogeneity between Euro area and Poland using a small two-country DSGE model. Regarding the parameters that are describing agents' behaviour he finds rather inconclusive differences, but he finds a large degree of heterogeneity in terms of volatility and synchronization of shocks hitting both economies. Gradzewicz and Makarski (2013) study the macroeconomic effects of losing monetary policy autonomy for the Polish economy, making use of a two-country Bayesian DSGE model. They find that euro adoption will have a noticeable impact on the Polish economic fluctuations; in particular the volatility of the output increases and the volatility of inflation decreases. They are, also, computing a welfare analysis and they find that the welfare costs of Euro adoption for Polish economy aren't large. Toroj (2011) tries to assess the stabilization capacity of competitiveness channel for the Poland economy and attempts a comparison with the Slovakian economy. He uses a DSGE models, but with a rather alternative mean of estimating, namely full information maximum likelihood estimation, which was proposed by Ireland (2001). He compares the impulse response function of the two economies and finds that Slovakia seems to be more capable of handling asymmetric shocks than Poland, in the case where both countries are in Eurozone. Moons (2009) tries to assess the losses that might occur from United Kingdom (UK) accession to the Eurozone. He finds that there is an important degree of heterogeneity in consumers' behaviour between these two economies but there is, also, a high degree of homogeneity in conducting monetary and fiscal policies. After computing the welfare loss, he finds that UK will lose significantly in terms of social welfare if it joins the Eurozone and the automatic stabilizers can play an important role in reducing these costs.

In Romania, there are a few papers that analyse the costs and the benefits of Euro adoption; Dumitru (2009) tries to evaluate the progress of Romanian economy from the perspective of real and nominal convergence. He finds that Romanian economy isn't prepared for Euro area accession and the progress in terms of real convergence must continue. Marinas et al. (2011) are trying to identify gaps in economic and commercial structures between Romania and Euro area and to see if the delay of Euro adoption after 2015 is justified. Also, they are testing for business cycle correlation between these two economies and they find an increased correlation of the business cycle fluctuations, mainly because of an increased industrial activity and export synchronization. They argue that there isn't an internal mechanism which is able to mitigate the external negative shocks and, thus, the Euro adoption for Romania might turn to be very costly. Marinas (2013) analyse the risk of euro adoption for the Romanian economy based on ten criteria. After analysing all the criteria, he finds that Euro adoption will have a negative impact on the entire economy, mainly due to the inability of the Romanian economy to adjust after an economic shock when the monetary policy tools are unavailable.

3. Overview of model equations

The model is built upon the previous work in the new open economy macroeconomics (NOEM literature)[(2)]. The model is relatively small and, thus, the most important parameters can be estimated. The model has standard neo-Keynesian features like sticky wages and prices, habit in consumption, investment adjustments costs. The dynamics of the model is driven by fourteen stochastic disturbances, seven for each economy, namely: *consumption preference shock, labour supply shock, investment efficiency shock, technology shock in tradable and non-tradable production, government consumption shock and monetary policy shock*. The setup is very straightforward, the home economy is linked with the foreign economy by the trade flows; there aren't other relationships between these countries and the rest of the world. The agents in the economy are distributed over the interval [0, 1], where [0, n] are living in the domestic country; n is the share of domestic GDP in foreign GDP[(3)]. The production of tradable and non-tradable goods is distributed over the same interval.

Now we are going to review the most important equations[(4)]. Because the foreign economy setup is very similar with the home economy, we will be presenting only the equations describing the home economy.

The consumption equation is given by:

$$c_t = \frac{h}{1+h} c_{t-1} + \frac{1}{1+h} c_{t+1} - \frac{1-h}{(1-h)\sigma} (r_t - \pi_{t+1}) + \frac{1}{(1-h)\sigma} (\varepsilon_{d,t} - \varepsilon_{d,t-1}) \quad (1)$$

where c_t is the level of consumption in the moment t, which depends on a weighted average of past and future consumption, on the ex-ante real interest rate $(r_t - \pi_{t+1})$ and on the disturbance term $\varepsilon_{d,t}$. Under the assumption of no external habit formation $(h = 0)$ and log utility in the utility function $(\sigma = 1)$ the consumption equation becomes a purely forward looking consumption equation. The disturbance term $\varepsilon_{d,t}$ displays changes in the intertemporal allocation of consumption and savings. A positive shock to the consumption preference raises the current consumption and decreasing the future consumption level. This shock follows a first order autoregressive process with i.i.d normal innovations:

$$\varepsilon_{d,t} = \rho_d \varepsilon_{d,t-1} + \eta_{d,t}.$$

The investment equation is given by the:

$$i_t = \frac{\beta}{(1+\beta)} i_{t+1} + \frac{1}{(1+\beta)} i_{t-1} + \frac{1}{S''(1+\beta)} (q_{T,t} + \varepsilon_{i,t}) - \frac{\gamma_i(1+\omega) + \gamma_c}{S''(1+\beta)} x_t \quad (2)$$

where i_t is the level of investment which is a weighted average of past and future investment, $q_{T,t}$ is the relative price of installed capital (i.e. Tobin's Q) and x_t is the internal exchange rate (the price of non-tradable goods relative to the price of tradable goods). Now turning to the parameters of the investing equation (which can be interpreted as the investment demand), β is the households discount factor, γ_i is the share of final tradable investment, γ_c is the final share of final tradable goods in the consumption basket. S'' is the investment adjustment costs; following Christiano et al. (2005) the capital adjustment costs is modeled as a function of changes in investment in order to capture the hump-shape response of investment to various shocks. Also, a disturbance term is present in this equation, $\varepsilon_{i,t}$ which can be interpreted as an increase in investment efficiency after the capital is installed. This shock, also, follows a first order stochastic process, similar to the consumption preference shock.

The capital accumulation equation is given by the:

$$k_{t+1} = (1-\tau) k_t + \tau (i_t + \varepsilon_{i,t}) \quad (3)$$

where k_{t+1} is the capital available for the next period, which depends on the last period capital minus the depreciation and on the last period investment which is available for the production process in the next period.

The wage equation is given by the following equation:

$$w_t = \frac{\beta}{1+\beta} w_{t+1} + \frac{1}{1+\beta} w_{t-1} + \frac{\beta}{1+\beta} \pi_{t+1} - \frac{1+\beta\delta_w}{1+\beta} \pi_t + \\ + \frac{\delta_w}{1+\beta} \pi_{t-1} + \frac{(1-\theta_w)(1-\beta\theta_w)}{\theta_w(1+\Phi_w\varphi)(1+\beta)} (mrst - w_t) \quad (4)$$

where w_t is the real wage, π_{t+1} is the next period inflation expectations and $mrst$ is the marginal rate of substitution between consumption and labour. The real wage is a function of expected and last period level of wages, expected and last period inflation rate and a mark-up over the marginal rate of substitution (the labour supply is assumed to be monopolistic). In this model wages are specified in line with Erceg et al. (2000) framework: δ_w is the indexation parameter for the last period inflation, θ_w is the Calvo probability for wage resetting Φ_w is the elasticity of substitution between different categories of labour and φ is the inverse Frisch elasticity. If θ_w is set to zero, the real wage is a constant mark-up over the marginal rate of substitution, also, the wage adjustment depends on the level of wage stickiness. When the wage indexation is zero ($\delta_w = 0$) there is no indexation with past inflation.

Because the model features price stickiness, in line with Calvo (1983) framework, the prices are adjusting slowly to their desire level. In the model there are two sectors which are producing tradable and non-tradable goods, and thus, profit maximization of the price setting firms give rise to two New-Keynesian Phillips curves:

$$\pi_{n,t} = \frac{\delta_n}{1+\beta\delta_n} \pi_{n,t-1} + \frac{\beta}{1+\beta\delta_n} \pi_{n,t+1} + \frac{(1-\theta_n)(1-\beta\theta_n)}{\theta_n(1+\beta\delta_n)} mc_{n,t} \quad (5)$$

$$\pi_{h,t} = \frac{\delta_h}{1+\beta\delta_h} \pi_{h,t-1} + \frac{\beta}{1+\beta\delta_h} \pi_{h,t+1} + \frac{(1-\theta_h)(1-\beta\theta_h)}{\theta_h(1+\beta\delta_h)} mc_{ht} \quad (6)$$

where $\pi_{n,t}$ is the inflation in non-tradable goods, which depends on lagged inflation and the expected inflation in this sector and on the price markup over the marginal cost, $mc_{n,t}$ (the firms are operating in monopolistically environment). δ_n is the level of price indexation with past inflation and θ_n is the Calvo probability of price resetting in the non-tradable sector. If indexation parameter is set to zero, the lagged inflation disappear form the Phillips curve and if there is no price stickiness the level of the prices is constant mark-up over the marginal cost. The

Phillips curve in the tradable sector is similar with the one from the non-tradable sector. The CPI inflation is composed of non-tradable inflation and tradable inflation and is aggregated using a CES function with the share γ_c.

And, finally, the model is closed with a simple monetary policy rule:

$$r_t = \rho r_{t-1} + (1-\rho)\left(\varphi_\pi \pi_t + \varphi_y y_t\right) + \varepsilon_{m,t} \quad (7)$$

which allows for additional interest rate smoothing ρ and targets the deviation of inflation from the target and the output gap. φ_π and φ_y are the central bank response to the deviation of the inflation and, respectively, the response to the output gap. $\varepsilon_{m,t}$ is the monetary policy shock.

The relation with the foreign economy is given by the international risk sharing equation and the real exchange rate equation.

4. Estimation procedure

This section covers the estimation procedure, the calibration of the model, the data used in estimation, the priors and the results of the estimation.

4.1. Bayesian estimation

The Bayesian technique allows for the use of prior information from early studies, on both micro and macro level, in the estimation of the parameters of DSGE model. Bayesian inference is summarized in one simple idea: the Bayes' theorem. The elements that appear in the Bayesian theorem are the data and the model, motivated either by the economic theory or by some other types of reasoning.

The model is composed by a parameter set θ, that defines the admissible value of the parameters that indexes the functions of the model – there are some restrictions that came from statistics and economic reasoning – a likelihood function, $p(y|\theta)$, that tells us the probability that the model assigns to each observation given the parameters values and a prior distribution, $p(\theta)$ that captures pre-sample beliefs about the value of the parameters.

Accordingly to Bayes' theorem the posteriori distribution is given by:

$$p(\theta|y) = \frac{p(y|\theta)p(\theta)}{p(y)}. \quad (8)$$

The likelihood corresponds to the joint density of all variables in the data sample conditional on the structural parameters of the model. Before evaluating the likelihood function, the DSGE model must be solved. A log linearized DSGE model with rational expectations can be cast in state-space representation, where observed variables are linked to the model variables through the measurement equation. At the same time, the state equation provides a reduced form of the DSGE model, mapping current variables to their lags and the i.i.d. shocks. The reduced form is obtained by solving for the expectation terms in the structural form of the model using a suitable method (e.g. Blanchard, Kahn, 1980, Sims, 2001). If a unique convergence solution exists the Kalman filter can be applied to compute the value of the log-likelihood function. The first step is to maximise the log likelihood function with respect to the parameters and to obtain an estimate for the mode of the posteriori distribution and the Hessian matrix evaluated at the mode (the Hessian matrix is an estimator for the variance-covariance matrix of the parameters); this step is performed using an optimization routine. Next, the posteriori distribution is simulated with Random Walk Metropolis (RWM) sampling method. The general idea of the algorithm is to generate a Markov-Chain that represents a sequence of possible parameter estimates in way that the whole domain of the parameter space is explored.(5)

For the estimation of this DSGE model we've used Dynare(6) model which estimates the model using the methodology described above. The posterior maximization was performed with Sims algorithm (csminwel); the algorithm uses a simple line search and randomly perturbs the search direction if it reaches a cliff caused by nonexistence or non-uniqueness of a stable rational expectation solution for the DSGE model. The posteriori distribution was approximated using Metropolis-Hastings sampling method. The reported estimates are obtain by applying five Markov chains, with 100.000 replication for each chain.(7)

4.2. Data, calibration and priors

The model is estimated using fourteen macroeconomic variables, seven for each of the two economies, namely: *real GDP, real households' consumption, real investment, real wage, inflation rate, internal exchange rate*(8) and *nominal interest rate.* The variables for the euro area (EA 17) where taken form the ECB website and for the Romanian economy from the Romanian National Institute of Statistics, the exceptions are: the inflation rate (HICP) and the internal exchange rate, for both economies the data were taken from the Eurostat website; the nominal interest rate (Robor 3M) was taken from the National Bank of Romania website and the European counterpart from the Euribor website. Because the model is a short term one, all the data are in logarithm difference and detrended. The entire variables are seasonally adjusted, except the series regarding the interest rates. After adjustments the length of the series is 49 observations, from 2000 Q2 to 2012 Q2.

As common in the DSGE literature some of the parameters are calibrated, this is done mainly because these parameters are weakly identified in the data and because of the short number of observations. The discount factor β is calibrated at 0.99 for both economies, which matches a 4% annual real interest rate. The elasticity of substitution between different types of labour ϕ_w is set at 11, which means a 10% mark-up over the marginal rate of substitution; it is assumed that labour unions in Romania can obtain a 10% raise in wages. The elasticity of capital input for the Romanian economy was set at η = 0.33 and for the Euro area was set at η = 0.30. The capital depreciation for both economies was set to τ = 0.025 which means an annual rate of depreciation of 10%.

The parameter which expresses the share of Romanian GDP in the Euro area GDP n is set at the value of 0.0108, which is implied by the Romanian nominal GDP relatively to the Euro area (EA 17) nominal GDP, averaged over the length of the series. The share of final tradable consumption for the Romanian economy γ_C and for the Euro area γ_C^* was set at the value of 0.6 and 0.52, respectively; this value represents the share of services and energy goods in the HICP basket. The share of final tradable investment goods for the Romanian economy γ_I and for the Euro area γ_I^* was set at 0.57, and 0.48, respectively, which corresponds to the share of non-construction share in total investment from 2000Q1 to the 2012Q2. The share of goods in tradable basket was calculated using the trade flows between the two countries, the value for the Romanian economy is α = 0.58 and for the Euro area is $\alpha*$ = 0.01. The rest of the parameters are calculated from the steady state equations or from the long term averages presented in the data; for example the share of private consumption in Romania was set to 0.7442, which corresponds to the average of the private consumption relative to the nominal GDP over the period taken in consideration. The rest of the calibrated parameters are presented in Table 1.

Table 1. *Calibrated Parameters*

Parameter	Value
Discount factor (*Romania*) – β	0.99
Discount factor *(Euro Area)* - β^*	0.99
Labour elasticity of substitution * (*Romania*) - ϕ_w	11
Labour elasticity of substitution * *(Euro Area)* - ϕ_w^*	11
Elasticity of capital input (*Romania*) - η	0.33
Elasticity of capital input *(Euro Area)* – η^*	0.30
Capital depreciation rate** (*Romania*) - τ	0.025
Capital depreciation rate** *(Euro Area)* – τ^*	0.025
Share of final tradable consumption goods (*Romania*) - γ_C	0.60
Share of final tradable consumption goods *(Euro Area)* - γ_C^*	0.52
Share of final tradable investments goods (*Romania*) - γ_I	0.57

Parameter	**Value**
Share of final tradable investments goods *(Euro Area)* - γ_I^*	0.48
Share of goods in raw tradable baskets (*Romania)* – α	0.58
Share of goods in raw tradable baskets *(Euro Area)* - (1-α*)	0.01
Share of Romanian GDP in Euro area GDP	0.0108
Share of consumption in GDP (*Romania)*	0.7442
Share of consumption in GDP *(Euro Area)*	0.5708
Share of investment in GDP (*Romania)*	0.2490
Share of investment in GDP *(Euro Area)*	0.2074
Share of Government consumption in GDP (*Romania)*	0.0889
Share of Government consumption in GDP *(Euro Area)*	0.2068

* wage mark-up of 10%.
**depreciation per quarter (10% per annum).

Now turning to the prior distribution, these distributions were set mainly in the line with the DSGE literature.(9) The prior distributions for the parameters are chosen in conformity with constrains on the parameter space implied by the economic theory. For the parameters bounded between 0 and 1, we've chosen beta distribution, this group is formed by the habit in consumption with the mean 0.5 and standard deviation of 0.1, the Calvo parameters with the mean 0.7 and the standard deviation of 0.1, the indexation parameters with the mean 0.5 and standard deviation of 0.1. Also for the autoregressive parameters of the structural shocks the beta distribution was chosen with the mean of 0.7 and standard deviation of 0.1. Regarding the standard deviations of the structural shocks, it is assumed that the shocks that are hitting the Romanian economy are three times more volatile and, thus, the prior mean is set accordingly. Finally, given the well-known weak correlation of structural shocks, the mean of the priors for the shock correlation was set to zero. The full list of prior distribution is presented in the left columns of Table 2 for the parameters and in the left columns of Table 3 for the structural shocks. The final means and standard deviations of the prior distribution were set after several optimization of the log likelihood and the choice was based on the marginal likelihood criteria and on the convergence charts.

4.3. Estimation results

The estimation results are showed in Table 2 for the structural parameters and Table 3 for the structural shocks. Because we use a two country DSGE models, the structural parameters for both economies are available to us and, thus, we will attempt to make a comparison of both economies based on the value of the parameters. Also, for the Romanian economy there aren't reliable papers in which

DSGE models are estimated and, thus, we can't compare our results with others; we will try to validate our estimates using economic reasoning.

Table 2. *Distribution of the structural parameters*

Parameter		Prior distribution			Posteriori distribution		
		type	Mean	std.	Mean	5%	95%
Preferences							
Habit in consumption (*Romania*)	h	beta	0.5	0.1	0.1439	0.0915	0.1948
Habit in consumption *(Euro area)*	h^*	beta	0.5	0.1	0.4205	0.2916	0.5480
Inverse elasticity of consumption (*Romania)*	σ	normal	2	0.2	1.8638	1.5619	2.1484
Inverse elasticity of consumption *(Euro area)*	σ^*	normal	2	0.2	2.4352	2.0899	2.7517
Inverse elasticity of labour supply (*Romania)*	φ	normal	2	0.2	1.9751	1.6533	2.2974
Inverse elasticity of labour supply *(Euro Area)*	φ^*	normal	2	0.2	1.9647	1.6517	2.2912
Adjustment costs							
Capital adjustment costs (*Romania)*	S''	normal	4	1.5	2.8400	0.9252	4.7470
Capital adjustment costs *(Euro area)*	S''^*	normal	4	1.5	1.9477	0.6074	3.2884
Adjustments of prices and wages							
Calvo – Wage (*Romania)*	θ_W	beta	0.7	0.1	0.6197	0.5088	0.7295
Calvo – Wage *(Euro area)*	θ_W^*	beta	0.7	0.1	0.6652	0.5667	0.7659
Wage indexation (*Romania)*	δ_W	beta	0.5	0.1	0.4431	0.2741	0.6081
Wage indexation *(Euro area)*	δ_W^*	beta	0.5	0.1	0.4358	0.2831	0.5886
Calvo – Non-tradable (*Romania)*	θ_N	beta	0.7	0.1	0.5231	0.4339	0.6120
Calvo – Non-tradable *(Euro area)*	θ_N^*	beta	0.7	0.1	0.7957	0.7429	0.8471
Non-tradable indexation (*Romania)*	δ_N	beta	0.5	0.1	0.4599	0.2903	0.6269
Non-tradable indexation *(Euro area)*	δ_N^*	beta	0.5	0.1	0.4083	0.2461	0.5619
Calvo – Exports (*Romania)*	θ_H	beta	0.7	0.1	0.3389	0.2320	0.4432
Calvo – Exports *(Euro area)*	θ_F^*	beta	0.7	0.1	0.6292	0.5069	0.7480
Exports indexation (*Romania)*	δ_H	beta	0.5	0.1	0.3821	0.2226	0.5396
Exports indexation *(Euro area)*	δ_F^*	beta	0.5	0.1	0.3252	0.1757	0.4669
Monetary policy							
Interest rate smoothing (*Romania)*	ρ	beta	0.7	0.1	0.5262	0.4222	0.6372
Interest rate smoothing *(Euro area)*	ρ^*	beta	0.7	0.1	0.6811	0.5764	0.7919
Inflation feedback (*Romania)*	ϕ_π	gamma	1.5	0.1	1.5489	1.3920	1.7110
Inflation feedback *(Euro area)*	ϕ_π^*	gamma	1.5	0.1	1.4813	1.3140	1.6434
Response to output gap (*Romania)*	ϕ_y	gamma	0.5	0.1	0.5929	0.4480	0.7524
Response to output gap *(Euro area)*	ϕ_y^*	gamma	0.5	0.1	0.5934	0.4168	0.7697

First, we start with the parameters regarding the consumer preferences; we observe a difference regarding the habit in consumption, 0.14 for Romanian economy, respectively 0.42 for Eurozone. This parameter reflects how households adjust the consumption in response to shocks hitting the economy, a small value relates to a quicker adjustment of the households consumption level. The smaller value for the Romanian economy can be attributed to the fact that Romania is an emerging market and it is subject to a larger volatility of the output. Also, after taken in consideration the last data sample of the Eurozone, the value for the habit in consumption in much lower, pre-crises estimates show a value for this parameter around 0.7 (Smets, Wouters, 2007). Regarding the inverse intertemporal elasticity of consumption, which can be interpreted as a relative risk adverse parameter (CRRA), measures the responsiveness of the growth rate of consumption to the real interest rate; if the real interest is rising the future consumption may be increased due to the increased savings. If the real interest is rising with 1%, the future consumption will rise with 0.53% for the Romanian economy and with 0.41% for the Eurozone. A higher value of the inverse elasticity of consumption means a higher level of risk aversion, thus the households from the Eurozone have a higher risk aversion than the Romanian counterpart. The inverse elasticity of labour supply is the same for both economies, this elasticity measures the level of hours worked with respect to real wages; the values for both economies are around 0.5.

Now, turning to the capital adjustment costs, the estimates for the Romania economy are higher than those of for the Eurozone counterpart, 2.84 respectively, 1.94. The capital adjustment costs are an important mechanism in the DSGE models, because it helps us to capture the hump-shape form of the capital input which appears after a disturbance in the economy. A higher value of this parameter represents a lower rate of adjustment, thus in Romania, after a negative disturbance of the economy, the capital input is returning more slowly to the equilibrium than in the Eurozone, this makes sense, because the Romanian economy is less “technological” than the Euro area.

Also, the model features friction like sticky wages and prices, in line with the Calvo (1983) framework. A household (the labour supply is organized in unions) or a firm receive the permission to reset their wages with the probability $(1-\theta)$ and they are choosing the same level of prices or wages. Those agents that do not receive permission to adjust their wages or prices are setting then by indexing with past inflation. The duration between adjustments is given by the following formula: $1/(1-\theta)$. The difference between Romania and Euro area regarding the duration of a wage contract is very small, around one month, in general, the duration of a wage contract for the Romanian economy is around two quarters and two months and for the euro area is around three quarters. This difference is so small that we can consider the duration of a wage contract in both economies to be the same; also, the indexation parameters with past inflation are the same, around 0.44. Turning to the adjustment of the prices, here we can observe some differences, for example, the prices in non-tradable sector in Romania are adjusting every two quarters, in contrasts with the period of five quarters between price adjustments in Euro area. The differences also continues in the tradable sector, where the duration between price adjustments for the Romanian producers is around one and a half quarters and for the Euro area is around two and a half quarters. The indexation parameters for the Romanian economy are higher than those of the Euro area which is in accordance with the economic reality; Romania had a long period of large inflation. The quickly adjustments in the tradable sector can be attributed to the exchange rate, as we know the exchange rate is volatile and thus affects the price levels of exported and imported goods. Also, a high adjustment rate of the prices means that the producers can quickly achieve their desired mark-up level.

Looking at the estimates for the monetary policy, we observe that the parameters are roughly the same; a larger difference can be observed at the value of the interest rate smoothing parameters, the value for the Romanian economy is smaller than the Eurozone counterpart, 0.52, respectively 0.68; this parameter reflects the importance given to the past inflation by the central bank. Taken in consideration the disinflation process that took place in Romania, it is normal that the curve of interest rate adjustments to be steeper than the euro area counterpart.

In Table 3 are showed the estimates for the structural shocks. When setting the priors we have made the hypothesis that the shocks that are hitting the Romanian economy are there times more volatile than those affecting the Euro area.

Table 3. *Distribution of the structural shocks*

Structural Shocks		**Prior distribution**			**Posteriori distribution**		
		type	**mean**	**std.**	**mean**	**5%**	**95%**
Autoregressive coefficients							
Productivity in tradable (*Romania)*		beta	0.7	0.1	0.3941	0.2219	0.5546
Productivity in tradable *(Euro area)*		beta	0.7	0.1	0.3642	0.2061	0.5163
Productivity in non-tradable (*Romania)*		beta	0.7	0.1	0.3185	0.1893	0.4358
Productivity in non -tradable *(Euro area)*		beta	0.7	0.1	0.3844	0.2332	0.5374
Consumption preference (*Romania)*		beta	0.7	0.1	0.5009	0.3437	0.6713
Consumption preference *(Euro area)*		beta	0.7	0.1	0.5981	0.4086	0.7795
Labour preference (*Romania)*		beta	0.7	0.1	0.3274	0.2028	0.4494
Labour preference *(Euro area)*		beta	0.7	0.1	0.2949	0.1814	0.4052
Government consumption (*Romania)*		beta	0.7	0.1	0.3749	0.2301	0.5142
Government consumption *(Euro area)*		beta	0.7	0.1	0.5082	0.3418	0.6691
Investment efficiency (*Romania)*		beta	0.7	0.1	0.3799	0.2520	0.4961
Investment efficiency *(Euro area)*		beta	0.7	0.1	0.3899	0.2564	0.5305
Standard Deviation							
Productivity in tradable (*Romania)*		inv. gamma	0.3	inf.	0.1133	0.0750	0.1503
Productivity in tradable *(Euro area)*		inv. gamma	0.1	inf.	0.0856	0.0376	0.1305
Productivity in non-tradable (*Romania)*		inv. gamma	0.3	inf.	0.1036	0.0703	0.1356
Productivity in non -tradable *(Euro area)*		inv. gamma	0.1	inf.	0.0359	0.0212	0.0494
Consumption preference (*Romania)*		inv. gamma	0.3	inf.	0.0915	0.0694	0.1139
Consumption preference *(Euro area)*		inv. gamma	0.1	inf.	0.0171	0.0139	0.0203
Labour preference (*Romania)*		inv. gamma	3	inf.	3.2343	1.2186	5.3300
Labour preference *(Euro area)*		inv. gamma	1	inf.	1.0133	0.3849	1.6477

Structural Shocks		**Prior distribution**			**Posteriori distribution**		
		type	**mean**	**std.**	**mean**	**5%**	**95%**
Government consumption (*Romania*)		inv. gamma	0.3	inf.	0.2734	0.2150	0.3305
Government consumption *(Euro area)*		inv. gamma	0.1	inf.	0.0388	0.0317	0.0451
Investment efficiency (*Romania)*		inv. gamma	0.3	inf.	0.7118	0.2658	1.1242
Investment efficiency *(Euro area)*		inv. gamma	0.1	inf.	0.0528	0.0220	0.0834
Monetary policy shock (*Romania)*		inv. gamma	0.1	inf.	0.0154	0.0129	0.0180
Monetary policy shock *(Euro area)*		inv. gamma	0.03	inf.	0.0047	0.0039	0.0054
Correlation of Shocks (Romania and Euro area)							
Productivity in tradable		normal	0	0.04	0.0088	-0.0571	0.0716
Productivity in non-tradable		normal	0	0.04	-0.0049	-0.0675	0.0610
Consumption preferences		normal	0	0.04	0.0161	-0.0520	0.0816
Labour preference		normal	0	0.04	-0.0235	-0.0866	0.0404
Government consumption		normal	0	0.04	0.0295	-0.0322	0.0945
Investment efficiency		normal	0	0.04	0.0269	-0.0395	0.0891
Monetary policy shocks		normal	0	0.04	0.0249	-0.0418	0.0906

The level of shock persistence (the autoregressive coefficients) seems to be roughly the same for both economies, with a slightly higher persistence for the Euro area. Also, the estimates show that the shock that are hitting the Romanian economy are three times more volatile, this results are conclusive because we observe a difference between the prior distribution and the posteriori distribution. As expected, the correlation of structural shocks between these two economies is very low.

5. A simulation – Romania accession to the Eurozone

For this exercise we make use of the estimates from the previous section and we calibrate the DSGE model. In order to simulate the accession of Romania to the Euro area we've dropped the internal monetary policy rule in favour to the ECB`s one and the exchange rate equation. We assume that after accession the Romanian economy will reach equilibrium(10) and we study the effects of internal originated asymmetric shock. In order to assess these effects we make use of the impulse response function and we compare the dynamics in both scenarios. Now, some methodological notes: (i) the economy is studied in the hypothesis of *ceteris paribus*, meaning that the effect of only one shock can be studied, (ii) it is assumed that the Eurozone is not affected by any disturbances and continues on its natural rate of economic growth; (iii) the system is shocked with the variance of the structural shocks, (iv) the results are reported in percentage deviation from the trend, and (v) the growth rates of the economic variables are expressed from quarter to quarter (chain base).

In Figure 1 is presented the adjustment that takes place after a positive consumption preference shock; this practically means a rise in the current level of consumption.

In the case where Romanian is not part of the Economic and Monetary Union (EMU), a rise in the consumption level increases the output but is crowding the investment level – on the demand side; on the supply side, the level of labour input increases. Because the labour input is rising the marginal cost is raising translating into a higher inflation rate, which is compensated by the central bank with a higher interest rate. We can observe some adverse effects when Romania is under common monetary policy, mainly because a positive consumption shock isn`t raising the level of output in Romania. In the case of a monetary union, transaction costs are absent and, thus, the households are inclined to consume foreign made goods, resulting in a drop of the Romanian GDP, a larger drop in the investment level and a drop in the capital input. The real wage tends to rise because of a slightly drop in the labour input. Because the production has dropped, the exports are also dropping accompanied by a rise in imports to satisfy the households' consumption needs. From this graph we may conclude that the Romanian economy isn`t competitive enough in comparison with the Eurozone.

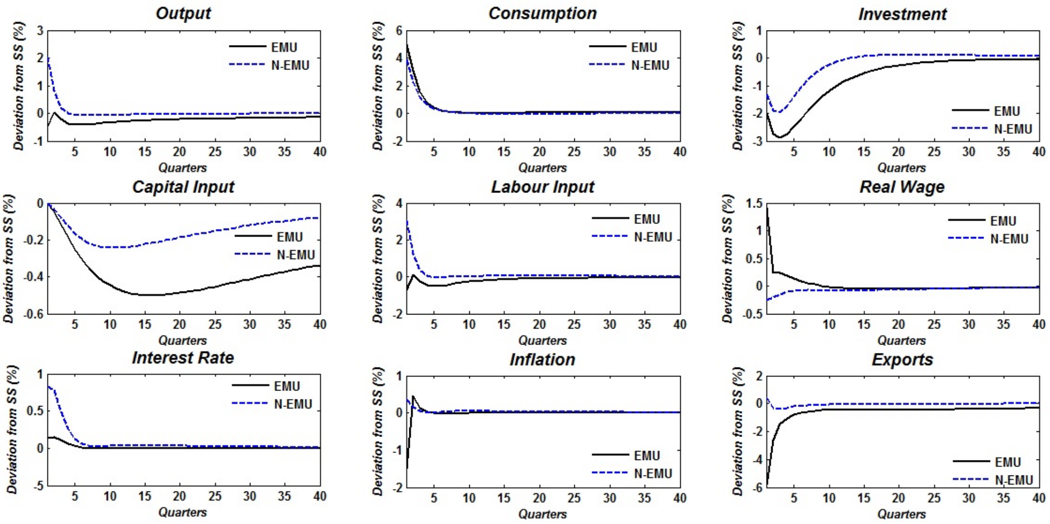

Figure 1. *Consumption preference shock*

In Figure 2 are plotted the adjustments after an investment efficiency shock. In the case where Romanian is not part of the EMU, after this shock, the investment and output are rising, mainly because the capital becomes more efficient. First, the consumption is declining, because the funds are diverted towards investment, but later is starting to rise. In order to meet the demand, producers are supplying more goods and, thus, translating in a higher labour input, capital input and, because the productivity is rising, in a higher real wage. Also, a positive effect of the increased productivity implies a smaller inflation. Under the EMU, the Romanian GDP is much higher mainly because of a raise in exports; being in a monetary union relates in lower transaction costs (in this case the exchange rate fluctuations). Also, the households have more available funds to raise their consumption, because firms are producing more and the dividends for the households are higher (households own all the firms in the economy). In the economy are available imported goods which in the first period are better than the domestic ones, but, when the new, more efficient, capital in available for production the domestic firms are getting more productive translating in a higher export rate. Also, because the ECB isn't responding to country specific problem, the inflation is rising and fades very slow. If we take in consideration that for the agents in the economy the volatility of the main economic variable isn't good, under EMU the output is higher but also the inflation is higher, in contrast when the Romania is out of the EMU the real GDP is also rising, but without a higher inflation rate.

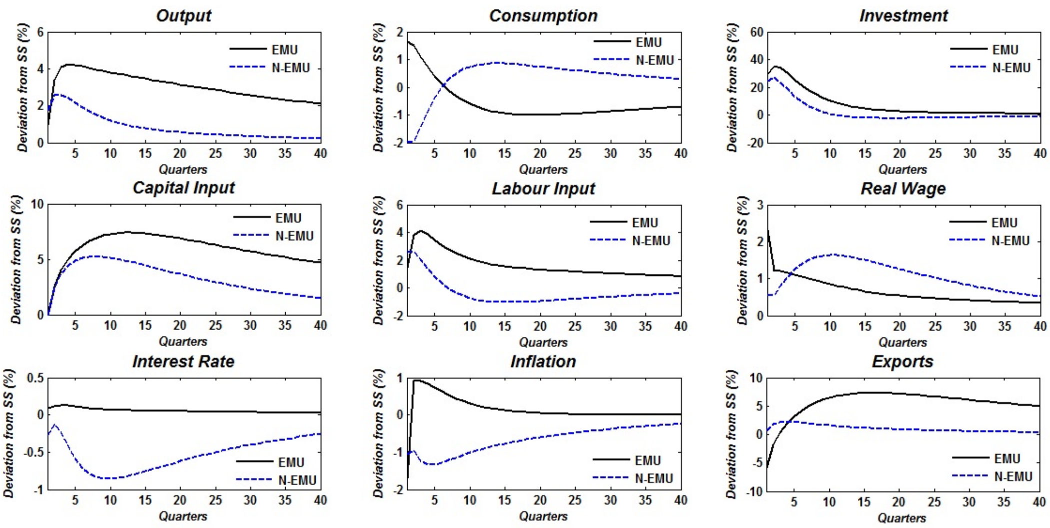

Figure 2. *Investment efficiency shock*

In Figure 3 the effects of a positive labour supply shock are plotted (i.e. households are shrinking their activity), which translates in the first case (N-EMU) in a reduction in output, consumption and investment. Because the real wages are rising, the marginal cost is also rising and, thus, the inflation is rising. The central bank is responding by raising the interest rate in order to compensate for a higher inflation rate.

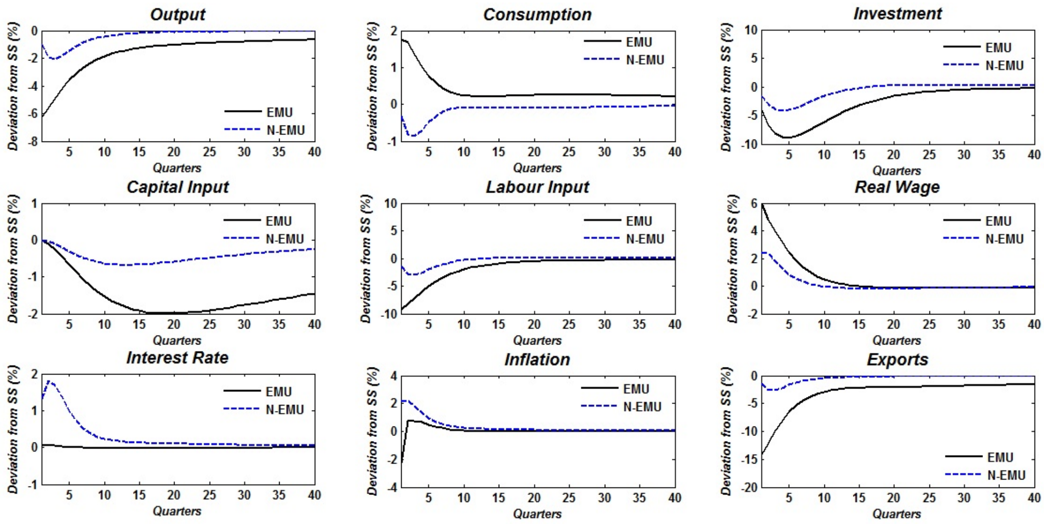

Figure 3. *Effects of positive labour supply shock*

In the case when Romania is a member of the EMU, the labour input is falling even more, resulting in a higher reduction in the GDP, a higher reduction of the investment and capital input. Because the home firms are producing fewer goods, also, the exports are falling. The labour input is falling even more which translates in a higher real wage and, thus, the households that are working are capable to compensate for the drop in consumption. In the case of a labour supply shock, when the monetary policy tools are unavailable, the effects of this adverse shock are even higher; the output is falling with almost 6% in the first period and after a longer period the GDP is returning to the equilibrium.

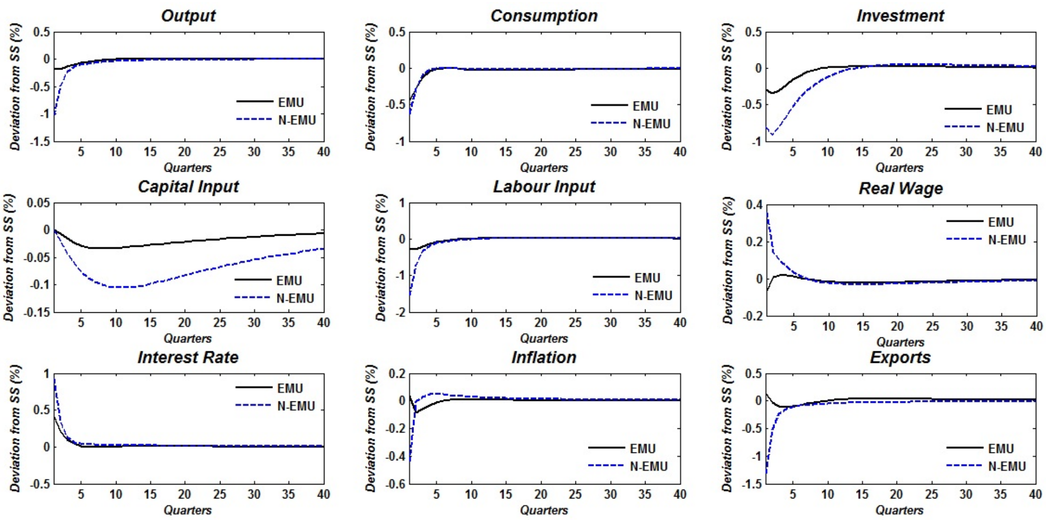

Figure 4. *Monetary policy shock*

In the case of a monetary policy tightening, plotted in Figure 4, the reaction of the economic variables are standard. As we observed from the previous section, National Bank of Romania (NBR) is targeting the inflation more aggressively (i.e. NBR sets the nominal interest rate higher) than the European Central Bank, having a more negative impact on the macroeconomic variables.

In the last two figures we present the effects of a technology shock in non-tradable production Figure 5 and in the tradable production Figure 6. An increase in efficiency in the non-tradable sector has a positive effect and, consequently, the output is rising. Because the rise in consumption is moderate, households have available funds for investment and, thus, the investment is rising. The positive effect of this shock continues with a drop in inflation because of a higher labour productivity.

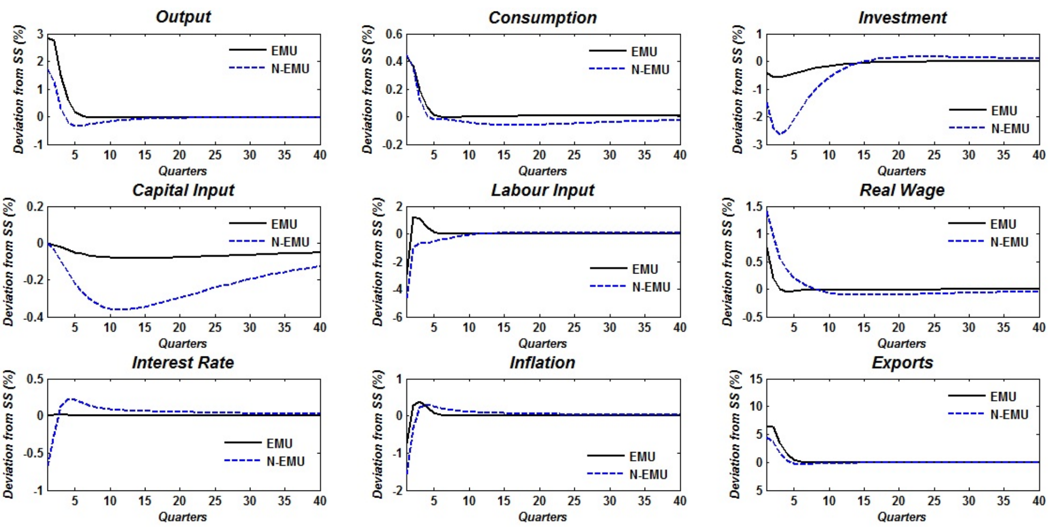

Figure 5. *Effects of a technology shock in no-tradable production*

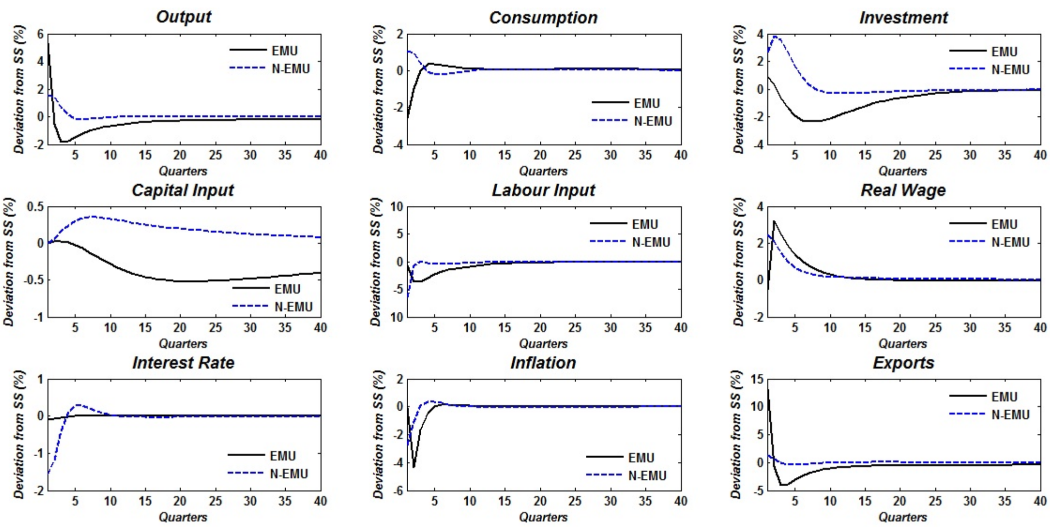

Figure 6. *Effects of a technology shock in tradable production*

When Romania is in EMU, this shock creates larger volatility in the main macroeconomic variables; in this case we observe a larger volatility in output, inflation, consumption and investment level. Also, in the first period the higher GDP is sustained by higher exports, but when the impact of the transitory technology shock fades, the output is falling and recovers very slowly. Turning to the tradable sector; this sector collects the main benefits from joining o monetary policy union. In this case, after a positive technology shock in tradable production (i.e. temporary increase in efficiency), when Romania is a member of the EMU the output is raising with more than one percentage, also, the higher GDP raise attenuates the drop in the investment rate resulted by the higher consumption rate. The increased level of the output comes with almost none adverse effects, like the rise in inflation, mainly because the increased level of wages are sustainable; the growth rate of wages is sustained by the increased productivity.

6. Conclusions and directions for further work

In this paper we have tried to analyse the impacts of internally generated shocks in the case where Romania is a member of the Economic and Monetary Union and comparing the results with the case where the monetary policy tools are available for the stabilization of the economy; for this purpose we make use of a two country DSGE model, linking Romania to the Eurozone. First we have tried to analyse the degree of heterogeneity between these two countries and we observed that there are a few structural differences, like: the habit in consumption parameter, the CRRA parameter, the capital adjustment costs and the Calvo probabilities; these differences arise from the fact that Romania is an emerging country with well-known periods of large inflation.

Now turning to the simulation exercise, only in the case of an increased efficiency in the tradable sector we observe some important benefits without any drawbacks; the output is rising without a raise in inflation. An important fact is that without the monetary policy tools (i.e. nominal interest rate and the exchange rate) the economy is unable to stabilise like in the case where these tools are available; this means that the competitiveness channel is unable to stabilise the economy proper and any volatility of the inflation and of the output creates losses in terms of households welfare; for example, in the case where Romania is a member of the Eurozone, after an positive labour supply shock the output is falling with almost four percentage and the recovery takes twice as longer than in the alternative scenario; also, a positive technology shock in non-tradable production creates a larger volatility of output, consumption and investment when Romania is a member of the EMU.

Because we've used a small DSGE model without financial markets, we were unable to study the impact of a reduction in the risk premium. This analysis can be done with a more complex DSGE model which takes into count the financial markets. Also, the fiscal policy is modelled in a simplistic way; it will be academic rewarding to remake this exercise and to study how the fiscal policy affects the economy in a monetary union. Finally, for a better understanding of the costs association with accession to Euro area, we'll need to compute a social welfare analysis where we can take in consideration all the changes that appear in the economy.

Notes

(1) An extensive report on benefits and costs associated with euro area accession for the Polish economy can be seen at: http://nbp.pl/en/publikacje/e_a/euro_adoptation.pdf .

(2) See Lane (2001), Gali and Monacelli (2005), Lubik and Schorfheide (2005).

(3) For a more detailed structure of the model see the original paper of Kolasa (2009).

(4) The equations are in log-linear form.

(5) For a more detailed discussion on Bayesian estimation for DSGE models see An and Schorfheide 2007, Villaverde (2009).

(6) For more information visit http://www.dynare.org/.

(7) The convergences of the Markov chains were asses using the diagnostic charts developed by Brooks and Gelman (1998) which are available upon request.

(8) Price of non-tradable relative to the tradable goods is based on the HICP basket, price of service and energy goods are treated as non-tradable.

(9) See Smets and Wouters (2002), Adolfoson et al. (2007), Christoffel et al. (2008).

(10) Immediately after accession it is large accepted in the literature that it will be a period of large inflation. We do not attempt to study the first effects of entering in Euro area; we rather try to study how the economy findsits equilibrium under the EMU after an internal originated shock where the monetary policy is unavailable.

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